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Robert E. Robinson, John W. Lindquist, Miles B. March, and Earl C. Pence

Horizons Technology, Incorporated

for

Manned Systems Group,
John F. Hayes, Chief

Systems Research Laboratory
Robin L. Keesee, Director

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MANPRINT IN LHX: ORGANIZATIONAL MODELING PROJECT

EXECUTIVE SUMMARY

Requirements:

To demonstrate the feasibility of using organizational modeling in the LHX (Light Family of Helicopters) program as an iterative tool to probe MANPRINT (Manpower and Personnel Integration) constraints beginning early in the system acquisition process.

To develop tools for rapid evaluation of proposed changes in LHX system design and/or unit mission requirements with manpower, personnel or training (MPT) implications.

Procedures:

An organizational model with four components was constructed to translate LHX ILS/RAM (integrated logistics support/ reliability, availability and maintainability) characteristics into mission capability for MANPRINT evaluation. The context used was the Attack Helicopter Company (AHC) in the Army of Excellence (AOE) Table of Organization and Equipment for the Air Assault Division (AAD) which is scheduled to become a LHX SCAT (scout/attack) helicopter pure unit. AHC mission definition, LHX ILS/RAM factor goals, administrative and logistics down times (ALDTs), probabilities of repair actions and maintenance functional allocations under LHX two-level maintenance were taken from the LHX RAM Rationale Report and the LHX Organizational and Operational Plan to ensure continuity with other LHX analyses in progress.

The first component module is an aircraft availability model. It uses the RAM characteristics of the LHX, probabilities by type of repair and associated ALDT to determine the capability of an AHC to satisfy mission availability requirements.

The second module is a unit capability model which compares unit resources on hand against minimum mission requirements by level of capability. It is used iteratively to develop a unit organization for combat that can sustain mission capability in proportion to its residual strength until degraded below minimum mission expectations.

The third module is a spread sheet representation of an AMC (Aviation Maintenance Company) maintenance manpower slice through division level. This model was patterned after the manpower analysis technique displayed in the LHX RAM Rationale Report but

it has the capability to allocate by MARC (Manpower Requirements Criteria) factors when such data are developed for the LHX.

The fourth module is a supply support spread sheet similar to the maintenance module except that it allocates class IX supply support.

Taken together these components comprise the MANPRINT mission capability model for top-down evaluation of MPT implications based on projected ILS/RAM. The model was exercised using RAM factor goals for LHX and an AHC 7-day, 8 LHX per mission requirement to establish a base case capability with the goal LHX. Three mission variants were also investigated to test the sensitivity of the developed organizational manning to the duration of continuous operations and to the number of LHX per mission. Manpower and personnel resources for each case were reviewed in comparison with those authorized in the AOE AAD AHC.

Findings:

The capability of the model to translate projected RAM data into mission capability was demonstrated.

Overall, organizational modeling with LHX goal factors suggests that MAA (Mission Area Analysis) flight hours for LHX can be supported in the AAD AHC (LHX) without *increasing current* AOE AAD manpower allocations.

A spread sheet program was developed to estimate resource status for mission capability and to investigate trade-offs between mission and RAM factors to achieve mission capability within constraints.

The probabilities of LHX repair actions and administrative and logistics downtimes obtained from the LHX RAM Rationale Report and used in the analysis, prevented the achievement of the full mission capability goal of providing 8 LHX per mission from the 11 LHX available in the AHC. These probabilities were found to be nonrestrictive when the full mission capability goal was changed to 6 LHX per mission and a minimum of 10 LHX available in the AHC.

Utilization of Findings:

This organizational model can be used iteratively to investigate MANPRINT implications of system and component alternatives with differing RAM or operating requirements at decision points. It can also guide development by identifying MANPRINT-leveraged design features for early attention. The spread sheet model makes it possible for program managers to discover and explore feasible regions for factor trade-offs in simple analyses run on a desktop microcomputer.

The scope of this project was limited to one LHX-pure unit but the process can be readily expanded to all unit types receiving LHX and extrapolated for total force analysis. Similar models can be structured from ILS/RAM and unit mission capability objectives early in any major weapon system procurement. This demonstration suggests that the use of this top-down approach for maintaining hardware development in close synchronization with program MANPRINT constraints from system conceptualization to full scale production is a viable option for program managers.

MANPRINT IN LHX: ORGANIZATIONAL MODELING PROJECT

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OVERVIEW

Background

The Army Systems Acquisition Process has witnessed many challenging trends during the last two decades. Declines in available manpower ceilings, escalations in project costs, and criticisms about declines in new system performance have fostered almost perpetual concern for the Army's ability to field improved systems.

During the Vietnam era, Southeast Asian requirements preempted substantial defense procurement funding. Vietnam force sustainment was financed by European drawdowns and cutbacks or suspensions of new system procurement. Fielding of new systems lagged behind the accelerated pace of the post-Korean conflict decade. Although the Army did take advantage of the Vietnam conflict to test some new systems and doctrines, it emerged from the experience with a sense of urgency to modernize its weapons and other equipment as well as its tactics and doctrines.

Although the Army's top management has accepted projected ceilings in quantities and qualities of future manpower and to some degree, escalations in project costs, they have mandated that declines in newly fielded system performance must be reversed. To that end, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has participated in many recent reviews of the Army systems acquisition process and the development of the emerging MANPRINT (Manpower and Personnel Integration) mandate and doctrine. ARI's Reverse Engineering Study (Marcus and Kaplan, 1984) identified problem areas in the acquisition process and reaffirmed the need for change in materiel systems acquisition philosophy. The issues are not new. They have haunted the community and have been key agenda items since the mid 1960's. A significant portion of the acquisition system performance shortfalls and cost increases can be attributed to the early neglect of manpower, personnel, and training (MPT) projection, examination and adjustment.

Early neglect or superficial treatment of MPT issues is exacerbated by the clear trend toward more complex and technologically sophisticated hardware. Frequently it results in demands on the personnel support and training systems that cannot be met. This typically places the acquisition process into a reactive mode. Weapon system design may have progressed too far to accommodate the problem economically. Accordingly, manpower, personnel, or training solutions are sought amid a very limited number and variety of potential alternatives. In this environment, "equipping the man" suffers.

A change in acquisition thinking was brought into focus by the Army which re-emphasized that it fields units not just materiel items. Accordingly, whenever a materiel item is

developed or changed, it has clear impact on how the system is packaged into a unit for application to combat missions. This packaging, in turn, has significant impacts on manpower, personnel, and training support requirements. Thus, to provide the comprehensive treatment cited above, methods which translate changes in system design into changes in unit/system packaging are necessary. Clearly this also has a reverse application; system designs achieving constrained MPT goals are advantageous for system production and fielding.

No one has opposed comprehensive treatment of MPT issues throughout the acquisition system process. As stated, it has been an agenda item for some time. But, until recently, the acquisition community has lacked formal methods which could enable the credible, comprehensive treatment necessary to achieve system cost and performance targets.

Research Objectives

The primary objective of this effort is to develop a portion of the analytic methods required to assess and plan for MANPRINT supportability. Specifically, it is intended to develop the necessary models and methodology to determine the inter-relationships and cross impacts of our sets of factors. The factors to be included in the model are: (1) materiel reliability, availability and maintainability (RAM), (2) integrated logistics support (ILS) planning factors, (3) mission capability and (4) MPT requirements. The second objective of the effort is to demonstrate the feasibility of the methodology developed by assessing the impact of the LHX (Light Family of Helicopters) RAM/ILS factors on manpower and personnel in a representative mission scenario. It is further intended that the results of the demonstration will be of significant use to the LHX acquisition planning community.

Scope

The current research effort represents one segment of a comprehensive research program designed to meet the MANPRINT challenge during the concept development phase of the Army's new LHX program. As such, this project will investigate and demonstrate the feasibility of modeling the dynamics of the mission and resource relationships within a target organization as a means to assess the manpower, personnel and training implications of introducing a new weapon system into the organization.

The LHX acquisition program is serving as the test bed for the methodology development conducted under this project. The Attack Helicopter Company (AHC) was chosen as the target organization because its employment doctrine and mission package are representative of the widest spectrum of LHX units and

because the unit itself provides a level of complexity which allows an unambiguous demonstration of the feasibility of applying the new methodology. The specific data relative to the LHX have been provided to both the LHX combat developers and materiel developers in the form of briefings and information packages.

Approach

ARI was asked by the LHX Program Manager's Office (PMO) to interpret RAM data for MANPRINT. In keeping with the Vice Chief of Staff's guidance to field units as opposed to weapon systems, the concept employed was construction of a model treating the weapon system (LHX) analytically as an organization for combat performing its mission. In order to maximize flexibility, the model consists of a series of modules, one for each major functional area within the target organization, put together in a building block fashion.

The requirement to analyze MPT supportability of a weapon system that was still in the concept exploration phase and thereby relate RAM/ILS to unit mission capability established a need for data in an environment in which neither the system nor the unit were well defined. Accordingly, coordinated agreement on baseline data was virtually impossible to obtain. In lieu of an illusive guarantee of an accurate, coordinated baseline, a top-down approach was used whereby a reference set of assumptions was developed. These assumptions must be continuously updated as more is learned about the system.

Once the assumptions were established, the steps described in the succeeding paragraphs were followed to define the relationships between RAM/ILS, unit mission capability and MPT factors.

<u>Step 1 - Identify Factors to be Established and Held Constant</u>. This step may be likened to a cost and operational effectiveness analysis (COEA) whereby effectiveness is held fixed and resources are varied to identify viable alternatives. In this case, the pertinent RAM/ILS factors and an appropriate set of mission factors were identified as the effectiveness measures.

<u>Step 2 - Identify and Define the Unit Type of Interest that Will Use the Materiel System</u>. It is here that a system definition process is initiated to bridge materiel system performance to organizational performance. The materiel and organizational system is viewed as a combination of personnel and materiel working together to accomplish a mission. An analytic modeling process, which works toward an optimized presence of people and things and enables the required mission performance, is used to define and represent the materiel and organizational system.

Step 3 - Define the Support Slice for that Type of Unit. This step identifies and allocates the appropriate share of combat service support (CSS) to the target organization. Included are those CSS resources and services provided in the tactical force structure which (1) are needed to sustain the effectiveness of the unit and its equipment when it is employed to perform the previously identified combat mission and (2) are affected by the introduction of the new weapon system.

Step 4 - Develop a Reference or Predecessor Set of Data Inputs. Two sets of reference data which represent the target organization before and after introduction of the new weapon system were developed. Later in the process, the MPT impacts were inferred from the comparison of the two sets of data. Ideally the references should be very precise descriptions of the unit. As a practical matter however, the dynamic nature of the Army force structure and doctrine required an arbitrary freeze of the "before" reference data at a point in time. The "after" reference data was based upon the best information available pertaining to the new system. As was previously mentioned, in many cases, data on the new system are predicated on a set of assumptions. Although the analyst is striving for the highest level of accuracy possible, identification of the relevant factors is the critical element of this step. So long as a complete set of factors is developed, the nature of the model ensures that the data itself can be updated as information becomes available.

There was some concern among the interested Army participants that developing the needed reference inputs amounted to de facto unit design. This analysis confined itself to the MANPRINT capabilities model and did not develop the comprehensive examination needed for a strawman unit design. However, based on the research objective of the present work and the capability of the methodology and its systems approach, the research team did attempt to infer a required personnel organization for combat.

Step 5 - Select Factors to be Varied to Optimize Resource Demands. The factors selected during this step will be systematically varied by the model in order to find the mix that makes optimum demands on the resources available to the target organization. The basis for selection are (1) criticality to the major functional area of interest (2) magnitude of the potential value range (3) a broad range of possible applications of the factor within the organization, and (4) known constraints on the factor.

Step 6 - Identify Factors to be Tested. Step 6 will identify factors that are expected to have an impact on MPT supportability but do not lend themselves to automatic variation by the model. Unlike the factors in step 5, these factors will be input changes to the reference data identified in step 4. These input factors change the parameters within which the systematic variations of step 5 are made.

Step 7 - Run the Model. Once steps 1 through 6 have been completed it remains for the user to run the automated sequences of the model and to analyze the outputs to determine MPT impacts, identify critical factors and the sensitivities of the critical factors to variations in the reference data.

The following are some of the products that result from the application of the systems approach just described:

- Projected change in MPT requirements from an assumed reference point.
- Sensitivities and uncertainties relating to key factors which may suggest additional model excursions.
- A statement about MPT feasibility for the system of interest.
- Trade-off algorithms, derived or estimated.
- Graphical and tabular portrayal of trade-off algorithms.
- Documentation and briefing of assumptions, findings, and observations.

The next section of this report describes the development and structure of the model in detail.

MODEL DEVELOPMENT

Modeling Objectives

The objective of the MANPRINT capabilities model is to serve as an analytical tool to be used in the assessment of the impact of design and management alternatives on MPT supportability. The model is intended to aid in the selection, generation or elimination of alternatives starting during the concept exploration phase and continuing throughout the acquisition cycle. In order to meet this goal, it must be flexible, relatively fast and require a minimum of automation expertise to operate.

Flexibility, speed and simplicity are required for several reasons, all of which derive from the objective of early MPT assessment. First, flexibility is required in order to stay in synchronization with the acquisition process. It is characteristic of materiel acquisition to start with a set of broad design and employment concepts and a set of general resource constraints and then to refine systematically the concepts which, in turn, more closely define the resource requirements and allocations. The model must be capable of adapting to the changes not only in data but in the target environment. Furthermore, it must be capable of operating in both a deductive and inductive mode. That is, it must be capable of quantifying the impact of alternatives as they are presented, as well as indicating a range of feasible alternatives within a given set of resource constraints. Moreover, it must be able to operate with incomplete or uncertain data and, as the weapon system matures, incorporate new data quickly.

The goals of flexibility, speed and simplicity must be met to enable widespread use of the model. Particularly during the early stages of the acquisition process, the range of alternatives is extremely broad and organizational affiliations and backgrounds of the personnel analyzing them vary widely. It is intended that, once fully developed, this model will be available to a wide range of analysts and will be used to compare and select the entire spectrum of alternatives. To achieve that end, the model must be fast enough to be responsive and must not require a special set of personnel or equipment to operate. Otherwise, a separate organization will develop to manage the model, increasing the coordination and level of consensus required before investigating an alternative, all of which is contrary to the philosophy of using the model in a "what if" mode.

Background Research

Prior to initiating the construction of the model, research was conducted to establish the context in which the model would

operate and to develop the framework for subsequent data collection. As was mentioned in the Overview, the LHX acquisition is serving as a test bed for the development of this portion of the MANPRINT methodology. Therefore the acquisition process as it is being implemented for the LHX was the focus of the research.

Investigation began with the LHX acquisition strategy in order to identify the major milestones anticipated and the timing of information requirements as well as data availability and sources. Once familiarity was gained with the LHX timetable, efforts were concentrated on obtaining as much information as possible on the LHX in terms of its design, employment and support. That effort resulted in the following:

1) Descriptive information pertaining to the hardware, technologies to be used, employment philosophy and concepts, support philosophy and concepts, weapon system goals and constraints, and the target audience.

2) Development of a list of issues and questions pertaining to the LHX.

3) Identification of methodologies used to analyze the various aspects of the LHX during development.

4) Identification of organizations and activities responsible for various aspects of the acquisition.

Once an adequate description of the LHX was established, the focus of the research effort was turned to the environment in which it would operate. This phase involved identification of:

1) Doctrine and regulatory guidance pertaining to Army aviation operations.

2) Existing force structure and missions.

3) Personnel descriptions and the personnel management system in general.

4) Unit, individual and collective training policy and procedures.

The results of the research were a description of the LHX and its anticipated support systems, a description of the environment in which development would take place and a description of the environment in which the system would operate. In addition, the effort identified issues and questions surrounding the LHX concept, and when answers would be required and by whom. The above served as the context for the modeling effort.

Model Structure

An analysis of the LHX program shows it to be an attempt at a great deal more than designing a new aircraft. The hardware will include the very latest technology, some of which is barely out of the concept phase itself. The project is also: (1) pioneering a major change in streamlining the acquisition process itself, (2) anticipated to alter markedly the military occupational speciality (MOS) structure within the Army Aviation Branch, (3) investigating methods to change completely the equipment training development process, (4) serving as the vehicle to investigate a major change in maintenance doctrine, and (5) being introduced into the recently organized Army of Excellence (AOE) force structure. Furthermore, it is the first major acquisition project for the recently organized Army Aviation Branch and is the first Army weapon system to implement the emerging MANPRINT doctrine at the earliest stages of development.

In short, at this point the LHX is a hypothetical system being introduced into an uncertain environment using new methods and procedures. As a result, the availability, applicability and accuracy of data has changed and will continue to change rapidly. It is also likely that the goals and objectives, particularly the RAM/ILS objectives, will change as the acquisition process for the LHX matures. These characteristics of the acquisition process suggest three requirements for the modeling methodology:

- A broad top-down approach. There is a need to be willing and able to understand MPT feasibility without initial achievement of MPT precision.

- An ability to do rapid sensitivity and uncertainty assessments, even after the research is finished.

- The avoidance of point estimates. Even the best point estimates are likely to be wrong, given sufficient time. Accordingly, the value of a point estimate analysis declines rapidly with time. In contrast, an assessment of a spectrum or continuum of feasibilities can still be valuable as an early estimation and is not only amenable to change, but recognizes the expectation of change. Results should be stated as much as possible in graphical terms and related to a feasibility continuum.

A simulation approach was chosen for the basic model structure with iterative refinement used to gain analytic fidelity. The overall model simulates the ability of the organization to perform its mission profile. This modeling process is required to incorporate a materiel and organizational system mission performance measure. Combinations of MPT alternatives realizing a consistent level of mission capability performance were considered equally effective.

The modeling process requires four model components to define mission capability demands on MPT. The model components are illustrated in Figure 1. Each of the modules is described below.

Mission Availability Module. The mission availability module simulates the effect of the mission profile on aircraft availability from a reliability failure perspective using the logic depicted in Figure 2. A model of the mission cycle has been joined to the wartime two-level maintenance administrative and logistics downtime (ALDT) model published in the LHX Ram Rationale Report.

Figure 3 is a summary representation of the model flow. The mission availability module is loaded with the number of aircraft in the organization and the mission requirements. The processor selects aircraft to fly according to time-phased mission requirements. It sends aircraft to maintenance based on hours flown and the mean time between essential maintenance actions (MTBEMA). Aircraft are routed through the maintenance structure and returned to a mission ready status according to the probabilities and delay times in the ALDT model.

Model output includes the aircraft sent on each mission, the number of times float aircraft were issued and a summary of mission and repair data. In turn, this generates a basis for operational, maintenance and supply work loads. These become the required organization for mission capability performance and are used as inputs to the next module.

Two versions of this module were developed. The first and primary version is a Monte Carlo simulation of the events previously depicted in Figure 2 and the second is a spread sheet. The simulation provides substantially more detail than the spread sheet in terms of when and how many times during the scenario a particular event occurred. However, in order to obtain valid information many (in this case more than 30) iterations must be run for every excursion. Therefore, compared to the spread sheet it is slow--approximately 2.5 hours versus seconds for the spread sheet. The simulation is the primary tool used to conduct detailed analyses and the spread sheet is the preferred tool when performing "what if" exercises. The input and output data for both versions are included in Appendix A.

Organization for Combat Simulation Module. The modeling procedure chosen for this module was the AMORE (Analysis of Military Organizational Effectiveness) methodology. Results of the mission availability module simulation established aircraft availability and manning requirements for operators, maintainers and support personnel. The organization for combat simulation module combines the availability of personnel and aircraft and compares them with the requirements of the objective mission capability. In this module, degradation resulting from combat losses as well as allowable personnel transfers are included in

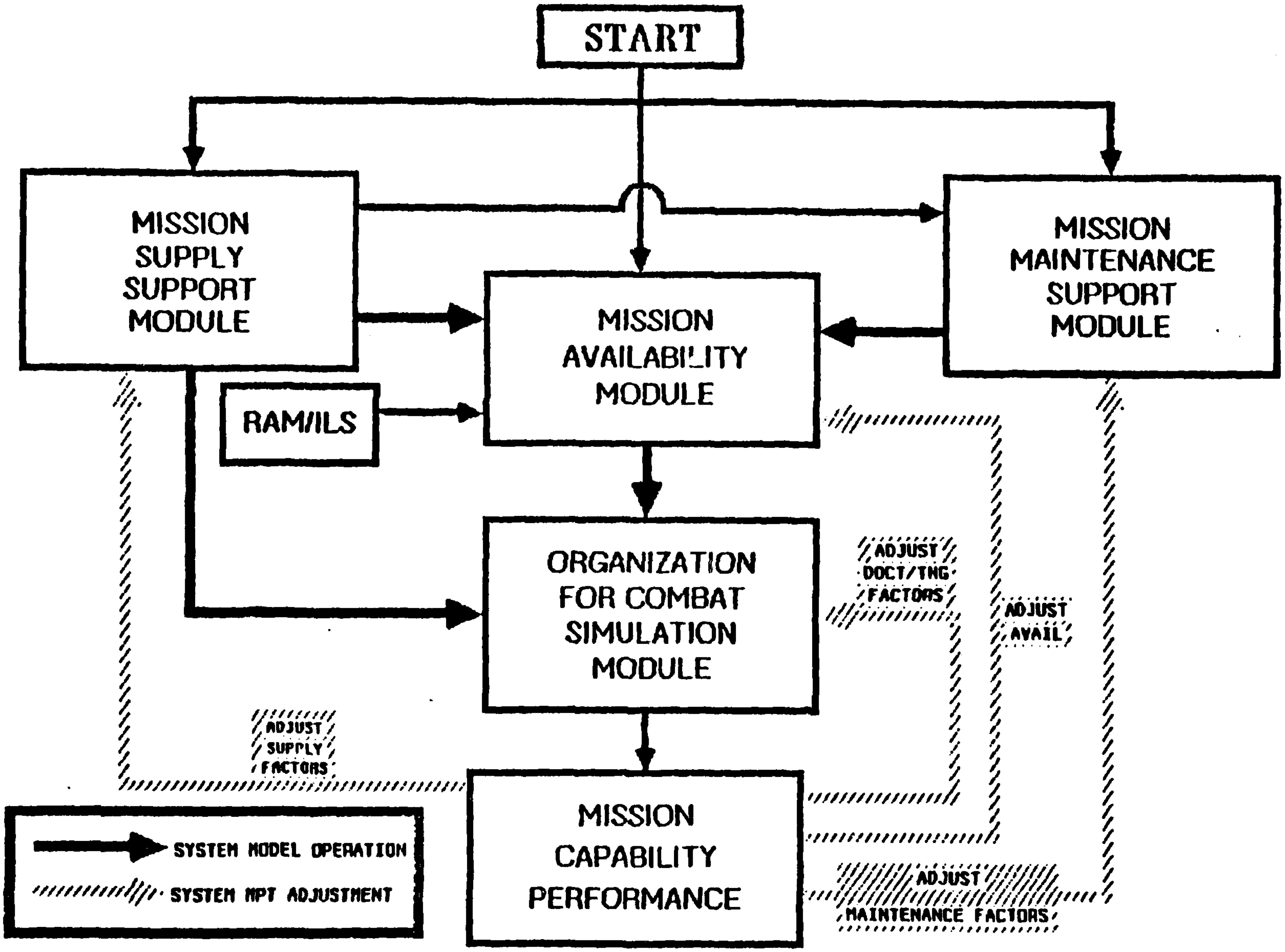


FIGURE 1. MANPRINT MISSION CAPABILITY MODEL

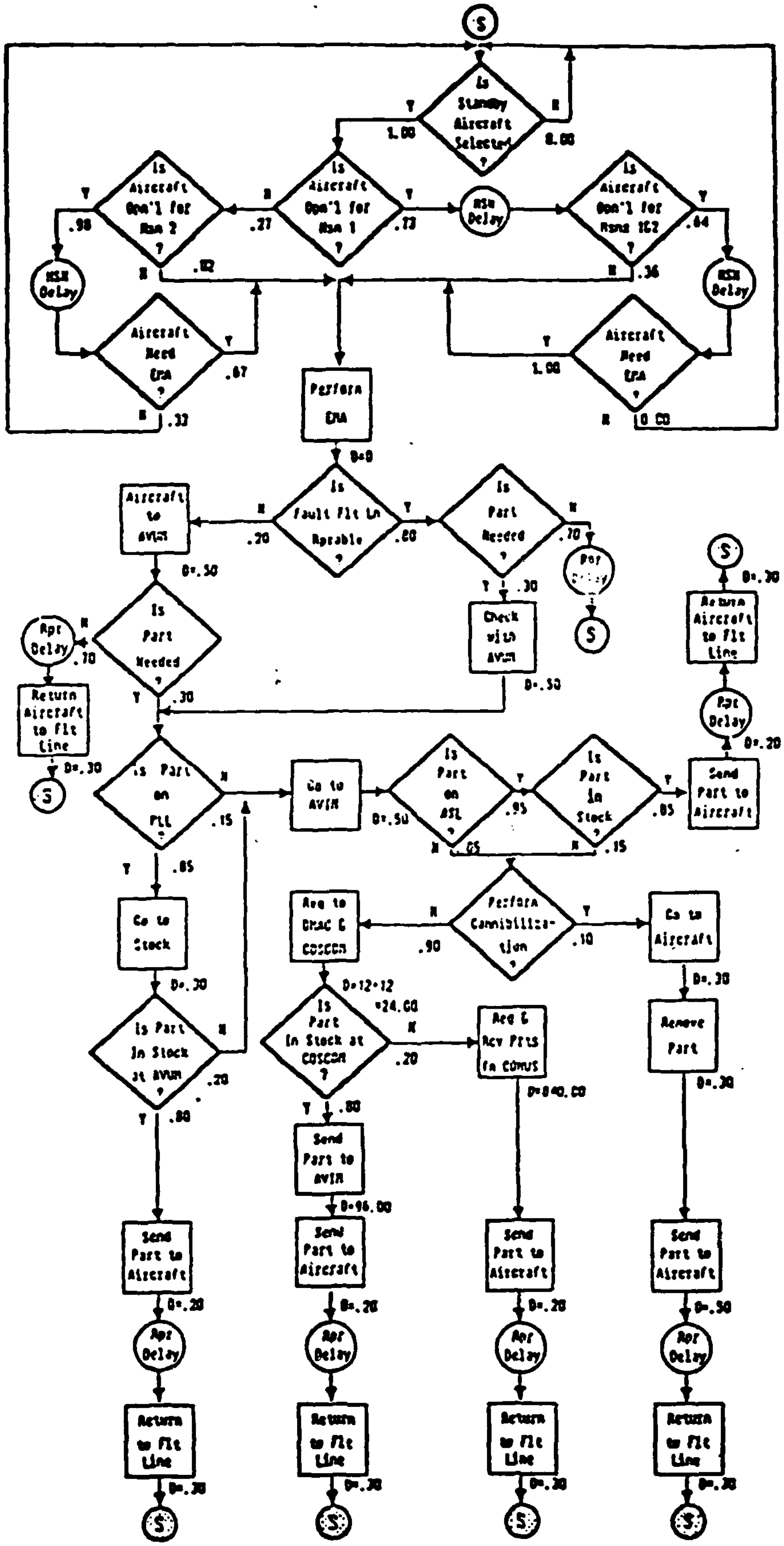


FIGURE 2. AHC AIRCRAFT AVAILABILITY MODEL

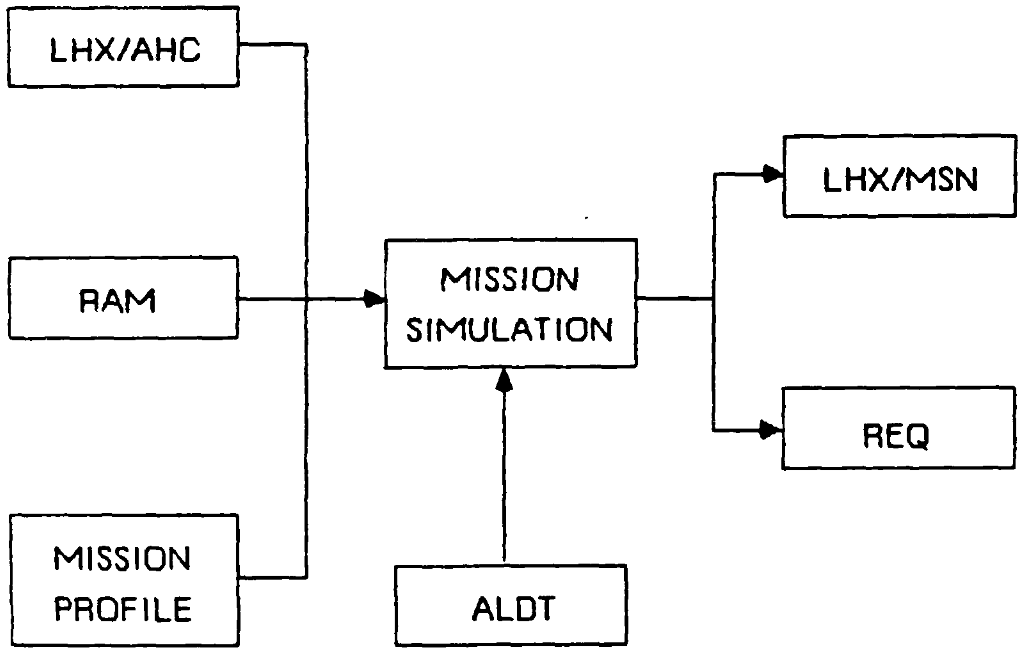


FIGURE 3. AIRCRAFT AVAILABILITY MODULE

the simulation. Figure 4 illustrates the organization for the combat simulation module.

The inputs required from the user for this module include a transferability table, degradation probabilities and damage probabilities developed by the analyst. The preprocessor allows the analyst to build and store alternative sets of inputs for later analysis. These sets of inputs or alternatives are referred to as unit data files. When called upon by the organizational capability simulator, the inputs stored in the unit data file are electronically loaded. The unit capability simulator transforms these data into unit capability distributions, expected assignment frequencies, expected assignment penalties and line item needs and surpluses. During the processing stage, the simulator can develop and save a set of survivors for each replication by sampling the initial strength using the degradation probabilities or the user can call a previously developed survivor file. At any time following the simulation, the user may print out the capability distribution, assignment frequencies, assignment penalties, and line item needs and surpluses. Each replication is automatically saved to the capability replication file.

It should be noted that AMORE used in the organization for combat simulation module was not prone to the inconsistencies that have plagued many earlier applications of the methodology. Many previous AMORE applications have suffered from a lack of understanding of the unit data file notion on the part of users. As a consequence, these analyses have fallen victim to a variant of the familiar GIGO (garbage in, garbage out) problem: the input is not well structured so the results of the analysis are ambiguous. In the organization for combat simulation module, considerable care was taken to insure that the unit data files were derived from explicit mission requirements and that the unit data files were structured to reflect the projected realities of the LHX organization. [See Fineberg, Hannon, and Helmuth (1984) for a discussion of problems with previous AMORE applications and recommended procedures for proper use of the model.]

<u>Mission Maintenance Support Module</u>. This module is a spread sheet which calculates maintenance requirements based on work loads identified in the foregoing two simulations. Figure 5 illustrates this module. The work loads are apportioned to the maintenance levels based on the maintenance concept for the weapon system. Once apportioned, the workloads can be converted to manpower using standard manning factors such as MARC (Manpower Requirements Criteria). In the event a standard manning factor is not available the work load may be calibrated to real or reference organizations. The products of this module are the maintenance personnel required and the maintenance man hours available per operating hour.

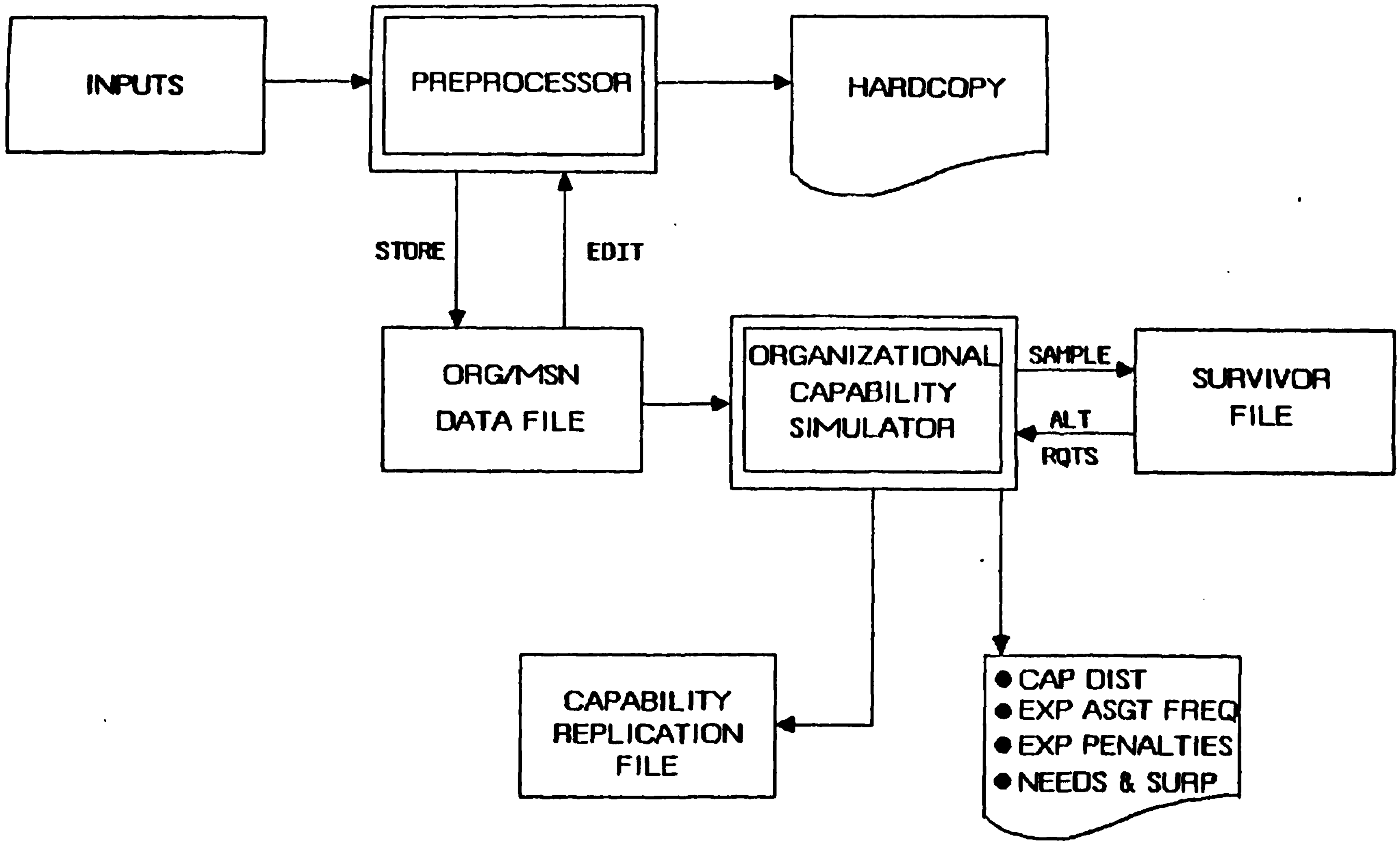
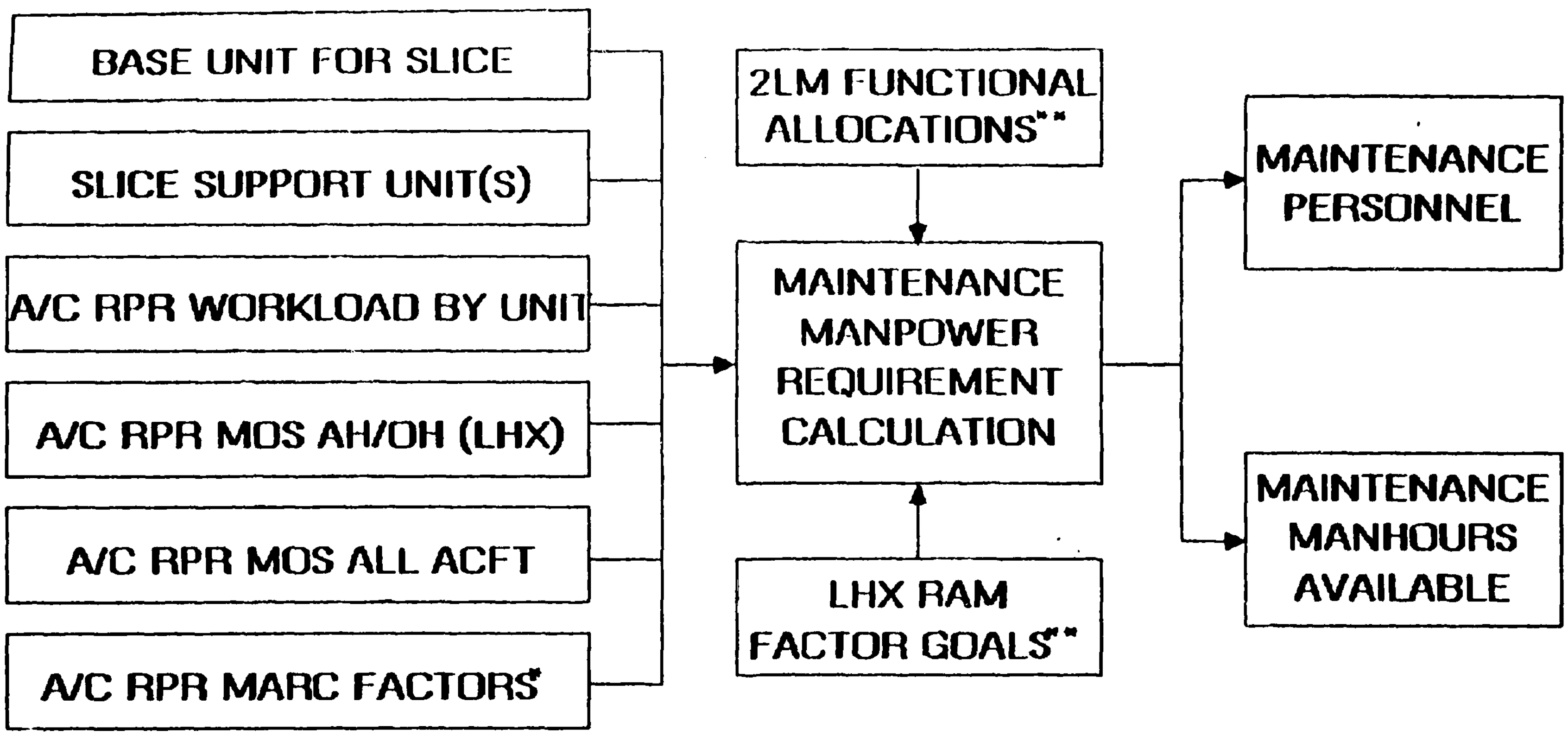


FIGURE 4. ORGANIZATION FOR COMBAT SIMULATION MODULE



*Initial application allocated in proportion to aircraft population (Manpower Analysis, RAM Rationale Report).
**Not required if LHX 2LM MARC factors are used

FIGURE 5. MAINTENANCE SUPPORT MODULE

Mission Supply Support Module. An additional model component, applicable at battalion level deals with the second type of support slice. It determines supply slice manning as a result of the supply requirements of the Attack Helicopter Company operating LHX at MAA (Mission Area Analysis) flying hour levels. MARC factors may also be used if available or, alternatively, supply support factors may result from calibration to real or reference units. Supply support calculation was beyond the initial charter for organizational level LHX examination. Supply space requirements do not exist at company level in aviation units. Supply support manpower requirement changes become more pronounced when integrating manpower requirements to division.

The four modules, when run sequentially, become the MANPRINT mission capability model. Although each module can be run independently, maximum utility is gained by using the outputs of one module as the input to the next.

The sequencing of the modules is not material as long as a complete set of inputs is made. There are three general sets of data resident within the model. The data sets are performance characteristics, mission capability and resources required. It is up to the user to select the two sets of factors to be held constant within each excursion. The third set of data will then be derived using the model. The analyst may then compare and analyze the outputs to establish the ranges of feasibility, sensitivities of data factors of interest to variations in other factors, and in some cases suggest additional factors to be tested or additional excursions required to complete the investigation of a particular factor. For example, when the model is used in the resource requirements mode, systematically varied iterations are run to seek the minimum resources needed to achieve the mission capability.

Tables 1 through 3 list the data elements for performance characteristics, mission characteristics and resources respectively.

Table 1

Performance Characteristics

1. Rate of assignment of operators
2. Rate of direct maintenance man-hours per calendar period
3. Rate of productive maintenance man-hours per calendar period
4. Mean time between essential maintenance actions (MTBEMA)
5. Mean time to repair (MTTR)

Table 1 (continued)

Performance Characteristics

---

6. RAM probabilities and delay times for:

   a. Repairs performed at the AHC:

      (1) without parts

      (2) with parts from the HSC prescribed load list

      (3) with parts from the Division authorized stockage list

      (4) with parts from controlled substitution

      (5) with parts located by an in theater lateral search

      (6) with parts from CONUS

   b. Repairs performed at the HSC:

      (1) without parts

      (2) with parts from the HSC prescribed load list

      (3) with parts from the Division authorized stockage list

      (4) with parts from controlled substitution

      (5) with parts located by an in theater lateral search

      (6) with parts from CONUS

7. Personnel transferability

8. Maintenance support available

9. Float:

   a. Criteria for issue

   b. Delay time for issue

Table 2

Mission Characteristics

1.	Duration of scenario
2.	Duration of mission
3.	Mission cycle (engagement versus standby)
4.	Equipment per mission
5.	Environmental condition

Table 3

Resources

1. Manpower
   a. Operators
   b. Maintenance personnel
2. Equipment
   a. Assigned aircraft
   b. Float aircraft

LHX MISSION CAPABILITY ANALYSIS

Objectives

As was discussed in the Overview of this report, the LHX acquisition is serving as the test bed for this research project. Therefore the primary objective of applying the mission capability methodology to the LHX is to determine the feasibility of the approach. However, in order to demonstrate feasibility, it is necessary to provide useful and timely analyses of a real world situation. Thus, the secondary objective of determining the MPT impact of the LHX RAM characteristics and ILS concepts enjoys the same importance as the initial objective.

Assumptions and Parameters

The current stage of development of the LHX precludes definitive data in any areas. In the absence of such data the assumptions and parameters listed below were used. It is important to remember that although the list of assumptions is fairly lengthy, the model was specifically designed to facilitate update as more information becomes available and/or as elements are changed.

1. It was assumed that the following constraints and goals will be achieved.

   (a) The LHX will achieve single-pilot operability.

   (b) The LHX will be maintained using two-level maintenance system.

   (c) The LHX-PMO ILS/RAM factor goals can be used to predict system capabilities.

   (d) The BIT/BITE planned for fault detection and isolation can achieve reliability objectives.

2. The key elements of the mission selected were as follows:

   (a) Continuous operations

   (b) Eighteen hour cycles consisting of two consecutive missions of three hours duration each and a twelve hour stand down after the second mission. (See Figure 6.)

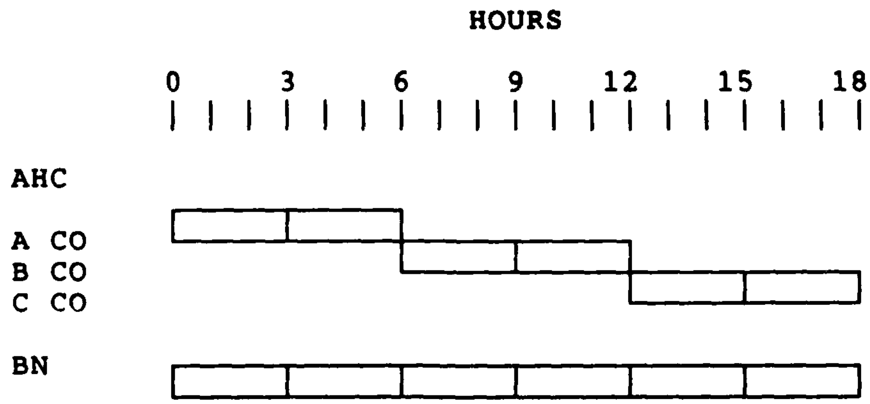


FIGURE 6. REPRESENTATIVE MISSION PROFILE

3. Aircraft Requirements

   (a) For comparability with current unit holdings and with other LHX analyses, the number of LHXs organic to an AHC was continued at 11.

   (b) Float LHXs were assumed to be provided to sustain unit operations when unit aircraft were NMCS (not mission capable supply).

4. Officer/Warrant Officer Pilot Requirements

   (a) 50% of flight operations were assumed to be conducted at night.

   (b) AR 95-1 crew endurance guidelines were followed.

   (c) For resiliency, the unit must be fully mission capable at 90% pilot strength.

5. Enlisted Requirements

   (a) As observed in the current AOE Table of Organization and Equipment, one repairer was required at AHC level per aircraft.

   (b) Similarly, the first sergeant, the two platoon sergeants and the headquarters section driver/radio telephone operator were continued for technical supervision and continuity of operations.

6. Personnel transferability to sustain unit capability under degradation was prioritized as indicated in Figure 7. In the absence of scenario specifics, all skill positions were accorded the same probability of degradation.

SKILL

SKILL #	1	2	3	4	5	6	7	8	9
1	0	2	2	10	5	5	10	10	10
2	1	0	1	10	4	4	10	10	10
3	2	1	0	1	6	6	6	10	10
4	3	3	3	0	7	7	5	6	6
5	7	8	10	10	0	1	3	5	5
6	8	7	10	10	1	0	2	4	4
7	9	9	10	10	2	2	0	2	2
8	10	10	10	10	10	10	1	0	1
9	10	10	10	10	10	10	10	1	0

= BASE CASE TRANSFERABILITY

0 = INDIVIDUAL PERFORMING HIS OWN JOB

SKILL #	MOSC	GRADE
1	15B00	CPT
2	15B00	LT
3	100()	WO
4	100()E/G	WO
5	67Z5M	E-8
6	67()40	E-7
7	67()20	E-5
8	67()10	E-4
9	67()10	E-3

FIGURE 7. ORGANIZATIONAL MODELING

7. The AHC was considered to be composed of a headquarters section and two identical LHX platoons.

8. The probabilities of LHX repair requirements and administrative and logistics downtimes as published in the RAM Rationale Report are assumed to be correct.

9. The LHX Operational and Organizational (O&O) Plan (Nov 85) functional description of LHX two-level maintenance (2LM)--user and depot--was used in conjunction with the FM 1-500 functional allocations for aviation three-level maintenance to project a functional allocation for LHX 2LM through user level. In the absence of a non-divisional AVIM (aviation intermediate maintenance) unit under 2LM, the Aviation Maintenance Company (AMC) was assumed to be responsible for holding and maintaining float aircraft at division level.

The development of the above assumptions was, in reality, done as the need presented itself throughout each step of the methodology development effort. For the purposes of discussion, it is being treated as if it was an independent process which preceded the application of the methodology described in the Overview.

Once the assumptions were in place the next step was to identify the factors to be held constant within each excursion. Since the objective of the performance demonstration was to assess the impact of RAM/ILS factors on MPT, the RAM/ILS factors had to be held constant and the MPT factors had to be permitted to vary. Allowing MPT to vary demanded that the mission capability also be held constant. Therefore, constant factors were as follows:

1. RAM/ILS:

   The rates of occurrence for failures

   The probabilities for the level that would provide repair parts

   Repair times

   Administrative and logistics downtimes

   The characteristics of the two-level maintenance concept

   Productivity of maintenance personnel

   Rate of allocation of support maintenance personnel to assigned aircraft

2. Mission:

Cycle length

Duration

Aircraft launched per mission

Flight condition as pertains to crew rest

Rates of degradation

Permissible personnel substitutions

Priorities of personnel substitutions

The Attack Helicopter Company was selected as the unit of interest for the reasons previously discussed. The Army of Excellence Table of Organization and Equipment was adjusted for the LHX. That is, authorizations pertaining solely to predecessor aircraft were deleted. Additionally the policy decision of retaining one repairer per aircraft, a first sergeant, two platoon sergeants and a driver/radio operator was followed. The number of aircraft assigned to each company was set at eleven.

Step 3, definition of the maintenance support slice for a more mature system would ordinarily be calculated from either engineering estimates of the rates of occurrence of the various types of failures pertaining to each repairer MOS or, if available, from the manpower authorization and requirements criteria. In the absence of both of those, the LHX maintenance support slice was defined as the share of the total maintenance support [AVUM (aviation unit maintenance) and AVIM] in an Air Assault Division (AAD) allocated to the predecessor aircraft in an Attack Helicopter Company adjusted for the LHX. Adjustments included elimination of capabilities rendered superfluous by the LHX and allocation of maintenance functions in accordance with the two-level maintenance concept as described in the O&O Plan. The procedure used to allocate the maintenance support parallels that described in the LHX Ram Rationale Report and is described in detail in Appendix B.

The next step in the LHX feasibility demonstration was to develop a reference set of data inputs based on the decisions and definitions occurring in the previous steps. Reference data as opposed to predecessor data are required because there is not a representative predecessor unit. The LHX scout/attack (SCAT) concept necessitates substantial changes in the organization and eliminates several operator, observer and repairer MOS. The introduction of technology and the two-level maintenance concept cause substantial redistribution of the maintenance workload. For those reasons, data from an AHC equipped with OH-58 and AH-1 aircraft will not suffice.

The data developed are shown in Tables 4 through 6. The data represent the base case used throughout this analysis.

Table 4

Performance Characteristics Base Case Data

---

1. Rate of assignment of operators:

   a. one per aircraft

   b. not to exceed the following duty periods and flying hours after adjustment for the environment relative factor as prescribed by AR 95-1

2. 4.89 direct maintenance man-hours per man per day

3. 6.85 productive maintenance man-hours per man per day

4. Mean time between essential maintenance actions (MTBEMA) = 4.5 flying hours

5. Mean time to repair (MTTR) = .05 clock hours

6. RAM probabilities and delay times for:

   a. Repairs performed at the AHC:

      (1) without parts - 56%, 0.5 hours

      (2) with parts from the HSC prescribed load list - 16.32%, 1.8 hours

      (3) with parts from the Division authorized stockage list - 6.2%, 2.0 hours

      (4) with parts from controlled substitution - 0.148%, 2.9 hours

      (5) with parts located by an in theater lateral search - 1.084%, 122 hours

      (6) with parts from CONUS - 0.266%, 866 hours

   b. Repairs performed at the HSC:

      (1) without parts - 14%, 1.3 hours

      (2) with parts from the HSC prescribed load list - 4.08%, 1.8 hours

Table 4 (continued)

Performance Characteristics Base Case Data

---

(3) with parts from the Division authorized stockage list - 1.552%, 2.0 hours

(4) with parts from controlled substitution - 0.037%, 2.8 hours

(5) with parts located by an in theater lateral search - 0.266%, 122.0 hours

(6) with parts from CONUS - 0.066%, 866 hours

7. Personnel transferability is allowed through priority 3

8. Maintenance support available

9. Float:

   a. Criteria for issue is anticipated downtime will exceed 24 hours

   b. Delay time for issue = four hours

Table 5

Mission Characteristics Base Case Data

---

1. Duration of scenario = 7 days

2. Duration of mission = 3 hours

3. Mission cycle = 18 hours with 2 missions back to back and 12 continuous hours of standby

4. Equipment per mission = 8 aircraft

5. Environmental condition = 50% day and 50% night which equates to an environmental relative factor of 1.4

Table 6

Resources Base Case Data

1. Manpower

    a. 15 operators per AHC

    b. 15 maintenance personnel per AHC

2. Equipment

    a. 11 assigned aircraft per AHC

    b. 2.3 float aircraft

The factors that were varied within the model were the personnel and equipment assignments to each mission. As missions are flown and degradation is experienced, the model will make personnel assignments within the criteria established (crew rest, transferability priorities, etc.) to optimize the resource demands. The equipment assignments were based on the aircraft availability criteria.

Four factors assumed to impact on mission capability were tested through modification of reference inputs. The four factors examined included:

Aircraft per mission

Simulation period

Personnel substitution criteria

Degradation rates.

Each excursion represents a change to the reference data or base case. Figure 8 lists the factors adjusted in the excursions. For clarity, the excursions are grouped by those employing 6 aircraft, those employing 8 aircraft and those varying the priority level acceptable when making personnel substitutions. The last line for each excursion is the associated mission capability expressed in terms of the average number of aircraft that the unit is capable of launching on a mission. Table 7 then lists the personnel and equipment resources that are required for the zero degradation excursions of the 6 and 8 aircraft sets of excursions.

EXCURSIONS

EXCURSION/ INPUT	1	2	3	4	5	6	7	8	9	10	11	12
AIRCRAFT	6	6	6	6	6	6	6	6	8	8	8	8
DAYS	7	7	7	7	30	30	30	30	7	7	7	7
% DEGRADATION	0	10	20	30	0	10	20	30	0	10	20	30
SUBSTITUTION PRIORITY PERMITTED	3	3	3	3	3	3	3	3	3	3	3	3
CAPABILITY AVERAGE AIRCRAFT LAUNCHED PER MISSION	6	5.6	5.0	4.2	6	5.4	4.6	4.3	8	7.1	5.8	5.1

EXCURSION/ INPUT	13	14	15	16	17	18	19	20	21	22	23
AIRCRAFT	8	8	8	8	8	8	8	8	8	8	8
DAYS	30	30	30	30	7	7	7	7	7	7	7
% DEGRADATION	0	10	20	30	20	20	20	20	20	20	20
SUBSTITUTION PRIORITY PERMITTED	3	3	3	3	4	5	6	7	8	9	10
CAPABILITY AVERAGE AIRCRAFT LAUNCHED PER MISSION	8	7.3	6.1	5	5.8	5.8	6	6.5	6.5	6.5	6.5

FIGURE 8. SUBSTITUTION PRIORITY

Table 7

Personnel and Equipment Resources

Personnel						
Job Title	GR	MOS	Basecase	Excur #1	Excur #2	Excur #3
Cmdr	O3	15B	1	1	1	1
Plt Ldr	O2	15B	2	2	2	2
SCAT Pilot	WO	100()	10	13	7	9
Acft Maint Tech & Armt Maint Tech	WO	100()E/G	2	2	2	2
First Sgt	E8	67Z5M	1	1	1	1
Plt Sgt	E7	67()40	2	2	2	2
SCAT Rpr	E5	67()20	3	3	3	3
SCAT Rpr	E4	67()10	5	5	4	4
SCAT Rpr	E3	67()10	4	4	4	4
Personnel Totals			30	33	26	28

Equipment				
	Basecase	Excur #1	Excur #2	Excur #3
Assigned Aircraft	11	11	10	10
Float	2.3	2.3	0	0

The float requirement shown indicates only that more aircraft are needed than are assigned to the unit. It is recognized that 2.3 float is probably an unrealistically high figure and therefore, true to the methodology, it suggests that additional excursions should be run to investigate other ways of controlling the aircraft requirement.

Because it is faster and easier, the spread sheet version of the aircraft availability module was used to investigate additional excursions that would result in a float requirement of

approximately 0.5 aircraft. The alternatives were selected by systematically varying values for factors affecting the float requirement until the desired number for float aircraft was reached. Table 8 displays a sample of the factors and alternative values that yield approximately 0.5 float while sustaining a full mission capability. Hours per mission, MTBEMA, and mission aircraft were varied independently. The delay to obtain repair parts from a theater search (theater delay) and from CONUS (Continental U.S.) were varied simultaneously. The detailed data pertinent to those excursions are included in Appendix A.

Table 8

Sample Alternatives

Factors	Base Value	Alternative Value
Hours/mission	3.0	2.6
MTBEMA (hours)	4.5	13.0
CONUS delay hours and	866.0	240.0
Theater delay hours	122.0	48.0
Mission aircraft	8.0	6.94

An alternative approach would have been to vary the factors in combination based on real world conditions and possibilities for improvement. However investigating those possibilities in detail was beyond the scope of this research project.

Once the products of the MANPRINT capabilities model were assembled it was possible for the analyst to assess the MPT supportability for LHX units. The data indicated that the MPT requirements of an attack helicopter company equipped with LHX aircraft are supportable if one assumes that (1) LHX program goals are achieved and (2) similar units equipped with predecessor aircraft are currently supported adequately. When the results obtained in the current effort are considered within the context of the LHX environment, several findings which support this conclusion emerge. These supportive findings include:

1. Less manpower is required than that required in similar units equipped with predecessor aircraft.

2. The unit is capable of sustaining the mission with the reduced manning.

3. Based on the minimal improvement in average aircraft per mission capability, the opportunity to increase the resiliency of the unit through additional cross training at the company level is virtually nonexistent.

4. The reductions in manpower will also reduce the supervisory requirement in that supervisory personnel of lower rank will be required.

5. The personnel required and the functions they perform are similar to those found in the predecessor unit.

ASSESSMENT OF MODEL

The principal conclusion drawn from this research effort is that the iterative simulation methodology represents a feasible and practical means to examine MPT supportability from the concept exploration phase of the Army system acquisition cycle through production and fielding. The results generated by the MANPRINT capabilities model are comparable to other parallel investigations including the COEA and HARDMAN (Hardware vs. Manpower) analysis. Furthermore, the objectives of speed and flexibility have been clearly demonstrated by the investigations into alleviating the float aircraft requirement as well as by the incorporation of large amounts of new information and altered assumptions throughout the duration of the project.

As was discussed earlier in this report, the LHX program is extremely complex and dynamic. In spite of this degree of complexity, the top-down approach used in the MANPRINT capability model enabled the research team to successfully define and quantify the relationships between and among the relevant factors. It was clearly demonstrated, however, that research to establish the environment and context for interpreting the model results are critical to its utility. That is, the model is not a black box that provides precise point responses to specific questions. In fact its greatest strength is that it establishes ranges of feasibility thereby preserving the greatest number of options. The attributes of those options may then be examined and compared repeatedly as the materiel system and the information surrounding it matures.

Another aspect of the methodology that met with great success was the translation of options into a common denominator expressed in terms of mission capability. It was determined that the relationships of the three major factors (performance characteristics, mission, and resources) can accommodate the necessary data elements to fully describe an organization. Furthermore if two sets of factors can be developed, the third can be derived. Again, however it is important to note that the preliminary research is critical to successful application of the methodology. First, it is essential to discover what information and facts do exist. Second, without the research reasonable assumptions cannot be formed to fill in the information gaps. If the assumptions are not reasonable, the results will not be credible.

In spite of the success of the methodology, the benefit of the specific model outputs was limited due to the simplicity of the target organization. Although the Attack Helicopter Company was selected to facilitate the construction and verification of the model, it also limited the applicability of the results. For example, the spectrum of personnel is limited to operators and repairers. The limited personnel spectrum virtually eliminated the prospect of increased efficiency or resiliency through additional cross training or consolidation of functions. The

model was shown to be capable of aiding such analyses and the research indicated that sufficient data are available for the model to function. The experience with modeling equipment factors was similar in that the opportunity to consolidate capabilities with the AHC did not exist because a single type of equipment, the LHX SCAT helicopter, was being employed and supported.

In light of the success of the current effort and the apparent applicability of the approach to more complex organizations and future stages of the weapon system acquisition process, it is the conclusion of this team that further development is warranted to optimize the benefits of the methodology. The MANPRINT capability model can be applied to any weapon system introduced into tactical organizations. The model has immediate relevance to ongoing MPT evaluations of major systems such as the LHX and Forward Area Air Defense System.

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APPENDIX A

SAMPLE AIRCRAFT AVAILABILITY DATA

APPENDIX A

SAMPLE AIRCRAFT AVAILABILITY DATA

Appendix A includes the data for the spread sheet aides investigation of alternative means of accomplishing the mission with approximately 5 float aircraft. A sample of the simulation data is also included for caparison of the spread sheet and simulation versions. The simulation data does not pertain to the float investigation.

SPREAD SHEET FLOAT INVESTIGATION

(HOURS PER MISSION)

MISSIONS/CYCLES	2	2
LHX HOURS/MSN	2.6	2.6
LHX MAA FH/DAY	6	6
TOE AIRCRAFT	11	11
MTBEMA	4.5	4.5
%CONUS DL	.0033	.0033
CONUS DLH	866	866
LHX/MSN	8	8
%THEATER DL	.0133	.0133
THEATER DLH	122	122
MISSION DURATION HOURS	168	720
MISSION DURATION DAYS	7	30
CYCLES	9.3333333	40
TOTAL MISSIONS	18.6666667	80
MISSION SORTIES	149.3333333	640
MISSION FH	388.27	1664
EXPECTED EMA	86.28	369.78
D/L SORTIES	37.17	159.30
SORTIES REQUIRED	186.50	799.30
SORTIES/AIRCRAFT	16.15	69.23
AIRCRAFT REQUIRED	11.55	11.55
TOE AIRCRAFT	11	11
FLOAT AIRCRAFT	.55	.55
FLOAT SORTIES	8.81	37.76

SPREAD SHEET FLOAT INVESTIGATION
(AIRCRAFT PER MISSION)

MISSIONS/CYCLE	2	2
LHX HOURS/MSN	6.94	6.94
LHX MAA FH/DAY	6	6
TOE AIRCRAFT	11	11
MTBEMA	4.5	4.5
%CONUS DL	.0033	.0033
CONUS DLH	866	866
LHX/MSN	8	8
%THEATER DL	.0133	.0133
THEATER DLH	122	122
MISSION DURATION HOURS	168	720
MISSION DURATION DAYS	7	30
CYCLES	9.3333333	40
TOTAL MISSIONS	18.6666667	80
MISSION SORTIES	129.5466667	555.2
MISSION FH	388.64	1665.6
EXPECTED EMA	86.36	370.13
D/L SORTIES	32.25	138.2
SORTIES REQUIRED	161.79	693.4
SORTIES/AIRCRAFT	14.00	60.00
AIRCRAFT REQUIRED	11.56	11.56
TOE AIRCRAFT	11	11
FLOAT AIRCRAFT	0.56	0.56
FLOAT SORTIES	7.79	33.40

SPREAD SHEET FLOAT INVESTIGATION
(CONUS &THEATER DLH)

MISSIONS/CYCLE	2	2
LHX HOURS/MSN	3	3
LHX MAA FH/DAY	6	6
TOE AIRCRAFT	11	11
MTBEMA	4.5	4.5
%CONUS DL	.0033	.0033
CONUS DLH	240	240
LHX/MSN	8	8
%THEATER DL	.0133	.0133
THEATER DLH	48	48
MISSION DURATION HOURS	168	720
MISSION DURATION DAYS	7	30
CYCLES	9.3333333	40
TOTAL MISSIONS	18.6666667	80
MISSION SORTIES	149.3333333	640
MISSION FH	448	1920
EXPECTED EMA	99.56	426.67
D/L SORTIES	11.87	50.86
SORTIES REQUIRED	161.2	690.86
SORTIES/AIRCRAFT	14.00	60.00
AIRCRAFT REQUIRED	11.51	11.51
TOE AIRCRAFT	11	11
FLOAT AIRCRAFT	.51	.51
FLOAT SORTIES	7.20	30.86

SPREAD SHEET FLOAT INVESTIGATION
(MTBEMA)

MISSIONS/CYCLE	2	2
LHX HOURS/MSN	3	3
LHX MAA FH/DAY	6	6
TOE AIRCRAFT	11	11
MTBEMA	13	13
%CONUS DL	.0033	.0033
CONUS DLH	866	866
LHX/MSN	8	8
%THEATER DL	.0133	.0133
THEATER DLH	122	122
MISSION DURATION HOURS	168	720
MISSION DURATION DAYS	7	30
CYCLES	9.3333333	40
TOTAL MISSIONS	18.6666667	80
MISSION SORTIES	149.3333333	640
MISSION FH	448	1920
EXPECTED EMA	34.46	147.69
D/L SORTIES	12.87	55.14
SORTIES REQUIRED	162.2	695.14
SORTIES/AIRCRAFT	14.00	60.00
AIRCRAFT REQUIRED	11.59	11.59
TOE AIRCRAFT	11	11
FLOAT AIRCRAFT	.59	.59
FLOAT SORTIES	8.20	35.14

AIRCRAFT AVAILABILITY
(SIMULATION VERSION)

RUN TITLE: NEW BASE CASE -- REVISED END MSN
RUN DATE: 03-31-1986 RUN TIME:11:13:15 REPLICATIONS: 100

TOTAL A/C: 11	A/C PER MSN: 8	GAME TIME: 72	REPAIR TIME: .5
MSN CYCLE: 18	MSNS/CYCLE: 2	HRS/MSN: 3	HRS BTWN MSNS: 0

FLT HRS BTWN EMA: 4.5 FLOAT THRESHOLD: 24
PRE-FLT TIME DELTA: 1 FLOAT TRANSIT TIME: 4

PROBABILITIES:
PASS PRE-FLT AFTER EMA - .73
PASS PRE-FLT AFTER MSN - 1
NEED EMA - FLT HRS<MAX - .2
NEED EMA - FLT HRS>MAX - 1
A/C RTNS FM MSN - 1
FLOAT A/C AVAIL - 1

EMA TRANSITION PROBABILITIES:

(PROBABILITIES ARE FOR A 'YES' ANSWER. THE ALTERNATIVE IS GIVEN IN PARENTHESIS.)

A/C FLT LN REPAIRABLE?.....	.80	(AVUM)
NEED PART FOR REPAIR?......	.30	(NO PART)
PART ON PLL AT AVUM?.......	.85	(GOTO AVIM)
PART IN STOCK AT AVUM?.....	.80	(GOTO AVIM)
PART ON ASL AT AVIM?.......	.95	(CANNIBILIZE)
PART IN STOCK AT AVIM?.....	.85	(CANNIBILIZE)
CANNIBILIZATION POSSIBLE?..	.10	(GOTO DEPOT)
ORDER PART FROM DEPOT?.....	.80	(GOTO CONUS)

****

TABLE OF AIRCRAFT AVAILABILITY *

CYCLE	MISSION	1	2	3	4	5	6	7	8
1	1							2	98
1	2						3	9	88
2	1						1	3	96
2	2					1	5	19	75
3	1							1	99
3	2					1	5	17	77
4	1								100
4	2					4	4	14	78

****

SUMMARY OF REPAIR & MAINTENANCE ACTIONS

TOTAL EMA'S FOR ALL REPLICATIONS.. 4514
AVERAGE EMA'S PER REPLICATION..... 45.14

	TOTAL EMA'S	AVERAGE EMA/REP	PERCENT OF TOTL
REQUIRED EMA TO PASS PRE-FLIGHT	628	6.28	.1391
FAILED PRE-FLIGHT (NO MISSION SINCE EMA)	464	4.64	.1028
FAILED PRE-FLIGHT (ON MISSION SINCE EMA)	0	0.00	.0000
REQUIRED EMA FOLLOWING MISSION	720	7.20	.1595
EXCEEDED MTBEMA	2702	27.02	.5986
REPAIRED ON FLIGHT LINE	3631	36.31	.8044
REPAIRED AT AVUM	883	8.83	.1956
REPAIRED WITHOUT PART/MODULE	3137	31.37	.6949
PART REQUIRED FROM AVUM	919	9.19	.2036
PART REQUIRED FROM AVIM	364	3.64	.0806
PART REQUIRED FROM DEPOT	73	0.73	.0162
PART REQUIRED FROM CONUS	21	0.21	.0047

****

* TABLE GIVES THE NUMBER OF REPLICATIONS IN WHICH THE INDICATED NUMBER OF AIRCRAFT WERE AVAILABLE FOR THE SPECIFIED CYCLE/MISSION.

REP NO.	NO. FLTS	REP NO.	NO. FLTS	REP NO.	NO. FLTS	REP NO.	NO. FLTS	REPNO. NO.	FLTS
1	0	21	0	41	1	61	0	81	1
2	3	22	3	42	2	62	0	82	1
3	2	23	1	43	2	63	1	83	0
4	1	24	0	44	0	64	0	84	1
5	3	25	0	45	0	65	0	85	1
6	2	26	1	46	1	66	3	86	0
7	1	27	0	47	2	67	0	87	1
8	1	28	0	48	3	68	2	88	0
9	0	29	0	49	2	69	1	89	1
10	1	30	1	50	0	70	0	90	1
11	0	31	1	51	0	71	0	91	1
12	1	32	2	52	2	72	0	92	3
13	3	33	1	53	1	73	1	93	2
14	1	34	1	54	1	74	1	94	1
15	1	35	1	55	0	75	1	95	1
16	0	36	1	56	1	76	2	96	1
17	0	37	0	57	0	77	1	97	0
18	2	38	0	58	1	78	1	98	1
19	1	39	2	59	1	79	0	99	1
20	2	40	0	60	1	80	0	100	1

AVERAGE NUMBER OF FLOATS PER REPLICATION: .94

APPENDIX B

LHX MAINTENANCE MANPOWER ANALYSIS

APPENDIX B

LHX MAINTENANCE MANPOWER ANALYSIS

1. PURPOSE

To provide an audit trail on the derivation of the 2.545 MMH/FH shown for the 8 LHX/MSN AHC base case at the ARI LHX Organizational Modeling Meeting on May 29, 1986.

2. METHODOLOGY (TWO STEPS)

- Step One.

  Identify the slice of maintenance effort (AVUM and AVIM) supporting an Attack Helicopter Company (AHC) in the Army of Excellence (AOE) TOE for the AAD. Total the maintenance personnel in the slice and calculate the maintenance ratio (MR) using MACRIT (AR 570-2), the mission flight hours required in the RAM Rationale Report tactical mission and the RAM Rationale Report Manpower Analysis Methodology. The share factor development is beyond the scope of this report but is fully discussed in the related Two Level Maintenance Research Report.

- Step Two.

  Modify the maintenance effort available to the LHX-SCAT predecessor systems according to the LHX-PMO projections for the operation and maintenance of the LHX and according to the LHX 2LM allocations described in the LHX O&O Plan. Total the maintenance manpower in an AHC (LHX) slice in an AAD equipped with LHX and compute the resulting MR as done for the AHC with the predecessor systems.

3. ASSUMPTIONS AND PARAMETER DEVELOPMENT FOR STEP ONE

a. Maintenance Personnel Counted - Eleven CMF 28 and 67 personnel in the units in an AHC's maintenance support chain in grades E3-6 were considered. Those working on LHX predecessor systems and a prorated share of those working on systems in all aircraft were counted.

b. Direct Maintenance Manhours Available - Calculated using AR 70-2 Methodology.

c. MOS Categorization - Where present, MOS populations were consolidated in two categories; Entry Level (E3-4) and Career Level (E5-6).

d. MOS Consolidation - All CMF 28 MOS were recorded as 35(), (confirmed by USASC action.)

e. Aircraft Maintenance Responsibility thru Division Level
AOE AAD Aircraft (TOE 67000L000)

AIRCRAFT	DIVISION	AMC	AHB(HSC)	AHC
SCAT/PREDECESSOR				
AH-1S	100	50	21	7
OH-58	91	45.5	13	4
	(191)	(95.5)	(34)	(11)
OTHER AIRCRAFT				
UH-1H	44	22	3	-
UH-60A	116	58	-	-
EH-60	3	1.5	-	-
CH-47D	32	16	-	-
	(195)	(97.5)	(3)	-
TOTAL	386	193	37	11

f. AHC Share Factors

AOE AAD AHC Slice (7 AH-1S + 4 OH-58A = 11 ACFT)

MAINTENANCE UNIT	AHC	HSC	AMC
ACFT SUPPORTED	11	37	193
AH/OH AIRCRAFT	(11)	(34)	(95.5)
OTHER AIRCRAFT	(0)	(3)	(97.5)
SHARE FACTORS			
AH/OH AIRCRAFT	11/11 OR 1.0	11/34	11/95.5
ALL AIRCRAFT	N/A	11/37	11/193

g. Aviation Maintenance MOS by Unit in AOE AAD AHC Slice

(1) AHC (TOE 01387L100)

CMF	MOS	TYPE SHARE	E3-E4	E5-E6	TOTAL
28	NONE				
67	67V	OH-58A	6	3	9
	67Y	AH-1S	4	3	7
	AHC Totals		10	6	16

(2) HSC (TOE 01386L100)

CMF	MOS	TYPE SHARE	E3-E4	E5-E6	TOTAL
28	35K	ALL	4	2	6
67	35P	ALL	-	1	1
	66J	AH-1S	-	1	1
	66V	OH-58A	-	2	2
	66Y	AH-1S	-	4	4
	67V	OH-58A	3	1	4
	67Y	AH-1S	9	2	11
	68B	ALL	1	1	2
	68D	ALL	1	1	2
	68F	ALL	-	1	1
	68G	ALL	2	1	3
	68J	AH-1S	5	2	7
	68M	AH-1S	5	2	7
HSC TOTALS			31	20	51

(3) AMC (TOE 01927L000)

CMF	MOS	TYPE SHARE	E3-E4	E5-E6	TOTAL
28	35K	ALL	2	1	3
	35L	ALL	9	3	12
	35M	ALL	5	2	7
	35P	ALL	-	4	4
	35R	ALL	12	3	15
			(28)	(13)	(41)
67	66J	AH-1S	0	2	2
	66V	OH-58A	0	2	2
	66Y	AH-1S	0	2	2
	67V	OH-58A	6	3	9
	67Y	AH-1S	9	5	14
	68B	ALL	11	5	16
	68D	ALL	6	4	10
	68F	ALL	5	2	7
	68G	ALL	11	5	16
	68H	ALL	2	1	3
	68J	AH-1S	8	7	15
	68M	AH-1S	8	4	12
			(66)	(43)	(109)
AMC TOTALS			94	56	150

h. Maintenance Ratio (MMH/FH) Calculation

(1) Annual Productive Manhours (APH) for maintainers in the AHC, HSC and AMC were all calculated at the Category I unit rate as in the LHX RAM Rationale Report methodology and converted to a daily rate as follows:

$$\frac{\text{CAT I APH}}{\text{days/year}} = \text{APH/DAY}$$

$$\frac{2500}{365} = 6.8493 \text{ APH per day}$$

(2) Direct Maintenance Manhours (MMH) per day were obtained by dividing the APH per day by 1.4.

$$\frac{\text{APH/day}}{1.4} = \text{MMH/day} \quad \frac{6.8493}{1.4} = 4.8923 \text{ MMH per day}$$

(3) Flying hours (FH) were taken as the number of hours which the 11 aircraft in one AHC would fly on the average in one day when the AHC is operating according to the continuous mission pattern for an AHB developed in the RAM Rationale Report. Each of the 3 AHC mount two consecutive 8 LHX missions of 3 hours duration in turn and, then, stand down for 12 hours until their turn comes around again. In this way, the AHB will have 8 LHX available at all times and can accumulate 8 x 24 or 192 FH in one day. Each AHC completes four 18-hour cycles every three days of continuous battalion operations which permits its average daily FH to be calculated as follows:

$$\frac{\text{\# cycles(MSN/cycle x LHX/MSN x FH/MSN)}}{\text{days}} = \text{FH/day}$$

$$\frac{4\ (2 \times 8 \times 3)}{3} = 192/3 \text{ or } 64 \text{ FH per day*}$$

*This is almost identical to the MAA FH rate (2094/365 = 63.1)

4. STEP ONE-QUANTIFICATION OF AN AOE AAD AHC SUPPORT SLICE

a. Figure 1 shows the quantification of the maintenance manpower supporting one AHC (7 AH-1S,4 OH-58A) through division level in the AOE AAD (TOE 67000L000). Totals have been indicated at three levels and cumulatively within the division. Similarly, a Maintenance Ratio (MMH/FH) has been calculated at each level and cumulatively. The calculations supporting line #1 (SHARE BASIS: ALL), line #3 (SHARE BASIS: AH/OH) and the MR at AMC are provided below to explain how the numbers displayed were derived.

DEVELOPMENT OF AN AHC MAINTENANCE SUPPORT SLICE IN THE AOE AAD (TOE 67000L000)

(1) LN#	(2) RPR SKILLS	(3) GRADE	(4) MOS	(5) SHARE BASIS	(6) AHC	(7) HSC	(8) AHC SHARE	(9) AMC	(10) AHC SHARE	(11) USER LEVEL TOTALS
1	AV/CE RPR	E5-6	35()	ALL	-	3	.892	13	.741	1.633
2	AV/CE RPR	E3-4	35()	ALL	-	4	1.189	28	1.596	2.785
3	AH/OH TI	E5-6	66()	AH/OH	-	6	1.941	5	.576	2.517
4	ARM TI	E5-6	66J	AH/OH	-	1	.324	2	.230	.554
5	AH/OH RPR	E5-6	67()	AH/OH	6	3	.971	8	.921	7.892
6	AH/OH RPR	E3-4	67()	AH/OH	10	12	3.882	15	1.728	15.610
7	ENGINE RPR	E5-6	68B	ALL	-	1	.297	5	.285	.582
8	ENGINE RPR	E3-4	68B	ALL	-	1	.297	11	.627	.924
9	POWERTRAIN	E5-6	68D	ALL	-	1	.297	4	.228	.525
10	POWERTRAIN	E3-4	68D	ALL	-	1	.297	6	.342	.639
11	A/C ELECTR	E5-6	68F	ALL	-	-	-	2	.114	.114
12	A/C ELECTR	E3-4	68F	ALL	-	1	.297	5	.285	.582
13	A/C STRUCT	E5-6	68G	ALL	-	1	.297	5	.285	.582
14	A/C STRUCT	E3-4	68G	ALL	-	2	.595	11	.127	1.222
15	A/C PNDRLC	E5-6	68H	ALL	-	-	-	1	.057	.057
16	A/C PNDRLC	E3-4	68H	ALL	-	-	-	2	.114	.114
17	FIRE CNTRL	E5-6	68J	AH/OH	-	2	.647	7	.806	1.453
18	FIRE CNTRL	E3-4	68J	AH/OH	-	5	1.618	8	.921	2.539
19	WPN SYSTEM	E5-6	68M	AH/OH	-	2	.647	4	.461	1.108
20	WPN SYSTEM	E3-4	68M	AH/OH	-	5	1.618	8	.921	2.539
	(UNIT TOTAL - AH/OH + ALL)				(16)	(51)		(150)		
		TOTAL AHC SLICE			16	+	16.107	+	11.866	= 43.972
		DAILY MMH (X4.8923)			78.277	+	78.798	+	58.052	= 215.127
		MR (MMH/64FH/DAY)			1.223	+	1.231	+	0.907	= 3.361

Figure 1. Aviation Maintenance Resources allocated to LHX predecessor systems in an AHC maintenance support slice in the AOE AAD (TOE 67000L000).

o <u>Line #1 Example (SHARE BASIS=ALL)</u>
<u>(REFERENCES: Paragraphs 3f-3h)</u>

(1) Column 8 is calculated by multiplying the number in column 7 by the share factor at HSC for <u>ALL</u> to obtain one AHC share of this skill at the HSC.

3 x 11/37 = 33/37 or .892 spaces

(2) Column 10 is calculated by multiplying the number in column 9 by the share factor at AMC for <u>ALL</u> to obtain one AMC share of this skill at the AMC.

13 x 11/193 = 143/193 or .741 spaces

(3) Column 11 shows the total skill spaces of this type in one AHC slice in an AOE AAD calculated according to the RAM Rationale Methodology.

AHC + HSC + AMC = Total in AOE AAD

0 + .892 + .741 = 1.633 spaces

o <u>Line 3 EXAMPLE (SHARE BASIS = AH/OH)</u>
<u>(REFERENCES: Paragraphs 3f-3h)</u>

(1) Column 8 is calculated by multiplying the number in column 7 by the share factors for LHX/Predecessor at HSC level to obtain one AHC share of this skill at the HSC.

6 x 11/34 = 66/34 or 1.941 spaces

(2) Column 10 is calculated by multiplying the LHX/Predecessor the AMC level times the number in column 9 to obtain one AHC share.

5 x 11/95.5 = 55/95.5 or .576 spaces

(3) Column 11 shows the space total through division level in this skill at this grade range justified by one AHC.

AHC + HSC + AMC = Total in AOE AAD

0 + 1.941 + .576 = 2.517 spaces

o <u>Maintenance Ratio (MR) at AMC (AVIM in AOE AAD)</u>
<u>(REFERENCES: Paragraph 3k)</u>

(1) The sum of the repairers in the AHC share at AMC level (column 10) is shown to be 11.866.

(2) This number is multiplied by 4.8923 to obtain the total maintenance manhours (MMH) available in an AHC slice at AMC level per day.

11.86 x .892 = 58.052 MMH

(3) The average FH per day in an AHC according to the RAM Rationale Report AHB continuous mission as 64 FH as explained in 3k above.

(4) The MR at AMC level is found by dividing the MMH available by the AHC average FH per day.

58.052/64 = .907 MMH/FH

b. The AOE AAD AHC support slice was found to have about 44 maintenance spaces supporting the 7 AH-1S and 4 OH-58A in one AHC which can provide 3.361 MMH per FH at the MAA rate. If the aircraft were exchanged on a one for one basis and all the predecessor system personnel were transitioned, these are the resources which would be dedicated to the 11 LHX in one AHC (LHX) company of an AOE AAD.

5. ASSUMPTIONS AND PARAMETER DEVELOPMENT FOR STEP TWO

a.-d. (see text at paragraphs 3a-3d)

e. Aircraft Maintenance Responsibility Thru Division Level

AAD (LHX) Aircraft (USAAVNC Projection)

AIRCRAFT	DIVISION	AMC	AHB(HSC)	AHC
LHX AIRCRAFT				
LHX-SCAT	176	88	34	11
LHX-U	47	23.5	-	-
	(223)	(111.5)	(34)	(11)
OTHER AIRCRAFT				
UH-60A	130	65	-	-
EH-60	3	1.5	3	-
CH-47D	32	16	-	-
	(165)	(82.5)	(3)	-
TOTAL	388	194	37	11

f. AHC Share Factors

AAD(LHX) AHC Slice (11 LHX-SCAT)

MAINTENANCE UNIT	AHC	HSC	AMC
ACFT SUPPORTED	11	37	194
LHX-SCAT	(11)	(34)	(111.5)*
OTHER AIRCRAFT	(0)	(3)	(82.5)
SHARE FACTORS			
LHX-SCAT	11/11 OR 1.0	11/34	11/111.5*
ALL AIRCRAFT	N/A	11/37	11/194

*LHX-U included with LHX-SCAT because of 70% commonality goal

g. Adjustments to AOE AAD Authorizations to Permit Calculation of an AAD(LHX) Slice (see note at end of section)

(1) AHC(LHX)

CMF	MOS	TYPE SHARE	E3-E4	E5-E6	TOTAL
28	NONE	-	-	-	-
67	67( )	LHX	9(-3)	3(-1)	12(-4)
	AHC TOTAL		9(-3)	3(-1)	12(-4)

CHANGE 67( ): -4 Observers/Repairers due to LHX single pilot operability concept.

(2) HSC(LHX)

CMF	MOS	TYPE SHARE	E3-E4	E5-E6	TOTAL
28	35( )	ALL	4	2(-1)	6(-1)
67	66J	LHX	-	1	1
	66( )	LHX	-	4(-2)	4(-2)
	67( )	LHX	9(-3)	3	12(-3)
	68B	ALL	1	1	2
	68D	ALL	1	1	2
	68F	ALL	0(-1)	-	0(-1)
	68G	ALL	2	1	3
	68J	LHX	5	2	7
	68M	LHX	5	2	7
		HSC TOTALS	27(-4)	17(-3)	44(-7)

CHANGES 35( ): -1 35P Supervisor due to reduced scope of AV-CE service at user level.

66(): -2 AH/OH Inspectors due to only 1 type of aircraft and limited nature of repairs at user level.

67(): -3 AH/OH Repairers due to only 1 aircraft, reduced scope of repairs, reduced time to repair and reduced number of repairs (longer MTBEMA). Remainder makes 3 teams of 1 NCO + 2 EM each.

68F: -1. Job can be done by 35K likely to be under utilized with LHX limits on AV-CE repair.

(3) AMC(LHX)

CMF	MOS	TYPE SHARE	E3-E4	E5-E6	TOTAL
28	35K	ALL	2	1	3
	35L	ALL	6(-3)	2(-1)	8(-4)
	35M	ALL	2(-3)	1(-1)	3(-4)
	35P	ALL	-	1(-3)	1(-3)
	35R	ALL	8(-4)	2(-1)	10(-5)
			(18)	(7)	(25)
67	66J	LHX	-	2	2
	66()	LHX	-	5	5
	67()	LHX	12(-3)	6(-2)	18(-5)
	68B	ALL	2(-9)	1(-4)	3(-13)
	68D	ALL	2(-4)	1(-3)	3(-7)
	68F	ALL	2(-3)	1(-1)	3(-4)
	68G	ALL	2(-9)	1(-4)	3(-13)
	68H	ALL	2	1	3
	68J	LHX	8	7	15
	68M	LHX	8	4	12
			(38)	(29)	(67)
AMC TOTAL			56(-38)	36(-20)	92(-58)

CHANGES 35(). + 0. TOE 01927L000 paragraphs 13, 14, and 15 have ASM 146 and 147 vans for shop repair and spare parts. Sixteen (16) spaces in MOS 35L, M, P and R were identified who supervise (35P) or repair AV-CE components. These were not shared for LHX because of the 2LM changes. The balance were considered adequate to be shared to provide all the user level maintenance function support required. Whether these 16 spaces can be eliminated can not be determined without investigating the needs of the other aircraft supported.

67(): -5. Sufficient numbers remain for six 3-man teams to provide forward assistance, controlled substitution and float maintenance to LHX units.

68B,D,F+G: +0. As for 35(), it is not clear this MOS can be reduced but only token efforts are needed for LHX. One NCO and two E3-4 were considered to be sufficient for the user level mission at AMC for LHX.

NOTE: All reductions shown to shared maintenance personnel are for calculation of an AHC (LHX) slice according to the LHX-PMO RAM goals for the LHX and the maintenance functions as allocated based on the LHX O&O Plan. Other aircraft being supported may mandate their retention.

h. (see text at 3h above)

i. <u>2LM Allocation of Maintenance and Supply Functions</u>

<u>User Level</u>

(1) Attack Helicopter Company (LHX Equipped)
- o Preventive Maintenance
- o Fault Isolation w/BITE
- o Remove/Replace LRU
- o CM/BDAR
- o Rigging for Recovery/Evacuation
- o On Condition/Planned Phased Maintenance on Aircraft

(2) Headquarters and Service Company (AHB-LHX Equipped)
- o Limited Corrective Maintenance
- o Remove/Replace LRU/QCA
- o CM/BDAR Assistance Including Quick Fix Repair
- o Recovery/Evacuation Assistance
- o Configuration Changes
- o Overflow/On Site Assistance to AHC
- o (LRU, QCA and Repair Part Supply)*
- o (Class III and V Supply)*

(3) Aviation Maintenance Company (AAD-LHX Equipped)
- o Maintenance Contact Teams
- o Recovery/Evacuation Assistance
- o On-Site Repairs
- o Controlled Substitution
- o Diagnostic/Prognostic Assistance
- o Float Aircraft Maintenance
- o CM/BDAR Assistance
- o (LRU, QCA, Repair Parts and End Item Supplies)*
- o (Packing/Unpacking Class IX Shipments)*

<u>Depot Level</u>

Maintenance Organizations (to be defined)

- o All Maintenance for Aviation Supply System
- o Major Overhauls, Rebuilds and Painting Requirements

- o (Class VII and IX Supply)*

*MOS outside CMF 28 and 67 not counted in AHC support slices.

6. STEP TWO-MODIFICATION OF AOE AAD FOR LHX

a. Figure 2 shows the development of the personnel spaces by level and the relevant MR for an AHC slice equipped with 11 LHX. Modifications have been made to the manning available at all three levels according to the LHX-PMO ILS/RAM goals and an allocation of maintenance functions according to the description of LHX 2LM in the LHX O&O plan. The rationale for these adjustments are presented in paragraph 5g above. Once these changes have been made, the methodology applied is the same as that used in Step One to identify the maintenance effort supporting the current AHC (7 AH-1S, 4 OH-58A) in the AOE AAD TOE.

b. The support slice as modified to the LHX-PMO ILS/RAM goals and the LHX 2LM as described in the LHX O&O Plan was found to yield 33 personnel in an AHC (LHX) maintenance support slice. Using the 64 FH per AHC per day developed in the AHB continuous mission profile, the resulting MR is 2.545 MMH/FH.

7. OBSERVATIONS.

a. While consistent with the manpower analysis reported in the LHX RAM Rationale Report, it is recognized that this methodology has three obvious flaws:

(1) It uses MACRIT now replaced by MARC.

(2) The MACRIT it uses is flawed in that the AMC, a CAT II unit, is only allocated CAT I hours.

(3) It allocates "ALL" aircraft maintenance effort by the difference in numbers of aircraft in the population and ignores the differences in maintenance requirements between types of aircraft.

b. MARC factors and proportional differentiation in the need for specific maintenance skills will be introduced in future applications.

DEVELOPMENT OF AN AHC MAINTENANCE SUPPORT SLICE IN AN AAD EQUIPPED WITH LHX

(1) LN#	(2) RPR SKILLS	(3) GRADE	(4) MOS	(5) SHARE BASIS	(6) AHC	(7) HSC	(8) AHC SHARE	(9) AMC	(10) AHC SHARE	(11) USER LEVEL TOTALS
1	AV/CE RPR	E5-6	35()	ALL	-	2	.595	7	.397	.992
2	AV/CE RPR	E3-4	35()	ALL	-	4	1.189	18	1.021	2.210
3	AH/OH TI	E5-6	66()	AH/OH	-	1	1.294	2	.493	1.787
4	ARM TI	E5-6	66J	AH/OH	-	4	.324	5	.197	.521
5	AH/OH RPR	E5-6	67()	AH/OH	3	3	.971	6	.592	4.563
6	AH/OH RPR	E3-4	67()	AH/OH	9	9	2.912	12	1.184	13.096
7	ENGINE RPR	E5-6	68B	ALL	-	1	.297	1	.057	.354
8	ENGINE RPR	E3-4	68B	ALL	-	1	.297	2	.113	.411
9	POWERTRAIN	E5-6	68D	ALL	-	1	.297	1	.057	.354
10	POWERTRAIN	E3-4	68D	ALL	-	1	.297	2	.113	.411
11	A/C ELECTR	E5-6	68F	ALL	-	-	-	1	.057	.057
12	A/C ELECTR	E3-4	68F	ALL	-	-	-	2	.113	.113
13	A/C STRUCT	E5-6	68G	ALL	-	1	.297	1	.057	.354
14	A/C STRUCT	E3-4	68G	ALL	-	2	.595	2	.113	.708
15	A/C PNDRLC	E5-6	68H	ALL	-	-	-	1	.057	.057
16	A/C PNDRLC	E3-4	68H	ALL	-	-	-	2	.113	.113
17	FIRE CNTRL	E5-6	68J	AH/OH	-	2	.647	7	.691	1.338
18	FIRE CNTRL	E3-4	68J	AH/OH	-	5	1.618	8	.789	2.407
19	WPN SYSTEM	E5-6	68M	AH/OH	-	2	.647	4	.395	1.042
20	WPN SYSTEM	E3-4	68M	AH/OH	-	5	1.618	8	.789	2.407
	(UNIT TOTAL - AH/OH + ALL)				(12)	(44)		(92)		
	TOTAL AHC SLICE				12	+	13.894	+	11.866	= 33.292
	DAILY MMH (X4.8923)				58.708	+	67.975	+	58.052	= 162.876
	MR (MMH/64FH/DAY)				.917	+	1.062	+	0.907	= 2.545

Figure 2. Aviation Maintenance Resources of the AOE AAD adjusted for maintnence of an LHX meeting PMO RAM Factor Goals in a 2LM system with function allocated as in the LHX O & O plan.